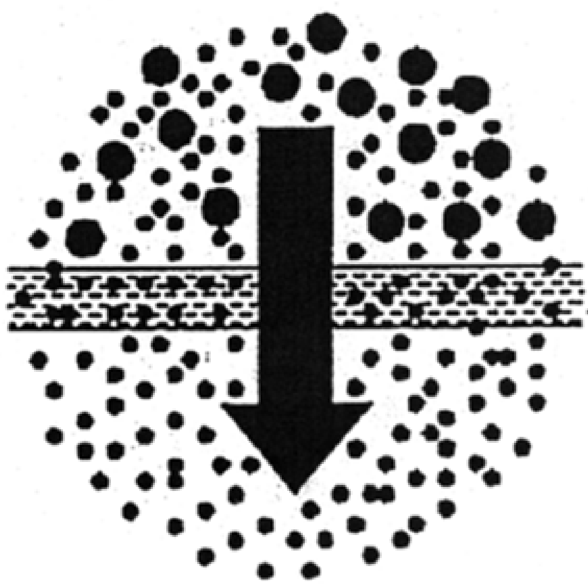
IMSTEC '92

INTERNATIONAL MEMBRANE SCIENCE AND TECHNOLOGY CONFERENCE

In Collaboration with the Australian Society for Biophysics

10 - 12 November 1992



PROCEEDINGS - EXTENDED ABSTRACTS

Edited by: A.G. Fane

**Published by: Centre for Membrane Science and Technology
University of New South Wales**

Design of Pilot Plant for Separation of CO_2 from Natural Gas Using Permeation Membrane

by

Hamdani Saidi, Ahmad Fauzi Ismail, Ramlan Abd. Aziz and Ariffin Aton*

Membrane Research Unit
Department of Chemical Engineering
Faculty of Chemical & Natural Resources Engineering
Universiti Teknologi Malaysia
Jalan Semarak, 54100 Kuala Lumpur
Malaysia

Introduction

Studies on carbon dioxide/methane mixtures separation using membrane technology are normally carried out using permeation cells utilising a very small membrane area. The application of the data obtained are usually limited to the operating conditions governing the experimental works namely feed flowrates, pressure, temperature and stage cut. In this study a pilot plant-sized membrane gas separation system was designed to generate carbon dioxide/methane data which are more reliable for field situation.

Design Consideration of the Operating Conditions

Previous study (Saidi, 1988; Saidi et al., 1990) observed that operating conditions namely throughput, feed and permeate pressures, temperatures and stage cut significantly affect the separation performance of the membrane system in designing the pilot plant. The magnitude of the operating condition was chosen closer to the field system.

Pressure and Temperature

Pressure and temperature affect performance and efficiency of a membrane separation system (Saidi et al., 1990). High feed pressure and temperature are usually preferred in membrane gas separation system. High feed pressure increases the driving force while high temperature increases the gas solubility in the membrane matrix thereby increasing the permeation rate or flux across the membrane module. The maximum allowable working pressure used was 70 bar. This necessitates the use of 316 stainless steel tubing and fittings. The system was designed to withstand temperature up to 60°C which was dictated by the limitation of the polymeric membrane used.

Throughput

The system is designed to handle the maximum throughput of 200 normal litre/hr (NL/hr) while permeation cell can handle only 20 NL/hr based on the membrane area of 20.3 cm^2 and permeability of pure gas of 13.09 x 10^5 cm^3 (STP)/cm^2s.cmHg in cellulose acetate (CA). Feed stream consists mainly carbon dioxide and methane. The permeate and retentate streams are enriched with carbon dioxide and methane respectively. The gas composition in each stream is analyzed by an on-line gas chromatography (GC).

Membrane Permeators

The membrane module represent the most important unit in the pilot plant. It consists of a housing constructed to withstand the designed pressure, and membrane module utilizing hollow-fiber and/or flat-sheet membranes. The length of the membrane permeator was chosen to reflect the variation of the pressure along the membrane surface as well as feed compositions. Feed and permeate pressure drop can be measured using pressure transducer. The data obtained is very critical to verify a flow mathematical model of the module.

Water and Hydrocarbon Saturators

Water and hydrocarbon saturators were included in this design to enable the pilot plant to use feed from sales gas. Natural gas after being processed of gas processing plant which removes water. By purging the feed through (H_2O) and (HC) saturators the feed humidity and Hydrocarbon content can be restored at feed conditions. (See Fig 1 for the detailed schematic diagram of the pilot plant).

Assumptions

The following assumptions are used in the design of the pilot plant: (1) Feed and permeate pressure drops in the membrane permeator are significant; (2) Water and heavy hydrocarbon exist in the feed gas; (3) Feed and permeate compositions vary along the membrane module; (4) Feed and permeate flowrates vary along the membrane module; (5) The system is operated under isothermal conditions.

Instrumentation

The instrumentation used in the design of the pilot plant can be divided into five categories, namely, measuring devices, safety system, on-line gas chromatography, data acquisition system and vacuum system.

Measuring devices consist of pressure gauges, pressure and temperature transducers, differential pressure transmitter, mass flowmeter, and gas regulators. The feed and permeate pressure and temperature are detected by a pressure and temperature transmitter respectively. Pressure and temperature transmitter will send an electrical signal to data acquisition system for LED display. The pressure drop between the feed and retentate stream is detected by a differential pressure transmitter. Pressure gauges are used to function as direct indicator of the system. The feed and permeate volumetric flowrates are measured by mass flowmeters (M1 & M2 indicated in Fig.1).

Safety system consists of four major components namely the hydrocarbon detector, relief valves, control valves and back pressure regulator. These instrumentations will ensure safety of the pilot plant from fire and explosion. Any gas leakage will be detected by the hydrocarbon detector which in turn will automatically close main inlet valve. System over pressure will be prevented by relief valve installed which were set at 70 bar maximum.

A continuous gas analysis of the permeate and retentate streams can be carried out using on-line Gas Chromatography. The data acquisition system automatically acquires, displays, stores and analyzes experimental data in a computer workstation.

To ensure that the pilot plant is free from the residue gas from the previous experiment, a vacuum system is installed for this purpose. The pilot plant is placed in the oven so that the operating temperature can be varied accordingly. Plate 1 shows the control panel of the pilot plant.

Conclusions and Future Works

In designing the membrane gas separation pilot plant, major consideration is given to ensure that the pilot plant can represent the real system and operate using real natural gas as feed. The pilot plant has the capability to operate continuously with the help of data acquisition system and an on-line Gas Chromatography. Future works will focus on performance of the pilot plants with respect to robust operating conditions similar to field operations.

Acknowledgement

The authors are thankful to Universiti Teknologi Malaysia and Petroleum Research Institute (PRI) for funding this project.

References

1. Saidi, H. (1988), "Separation of Simple Gases Using a Spiral Wound Membrane Permeator". Ph.D. Thesis, Department of Chemical Engineering University of Bradford, UK.

2. Saidi, H. and Svarousky, L. (1990), "Effects of Operating Conditions on the Performance of a Single Stage Spiral-Wound Membrane Permeator", Gas Separation Technology, Vansant, E.F. and Dewolfs, R. (Eds), 465-470.

3. Saidi, H., Chieh, L.K., Tahir, I. and Aziz, R.A. (1990), "Gas Separation Using Membranes - Analysis of Pilot Plant Data", Vansant, E.F. and Dewolfs, R. Gas Separation Technology, 471-475.

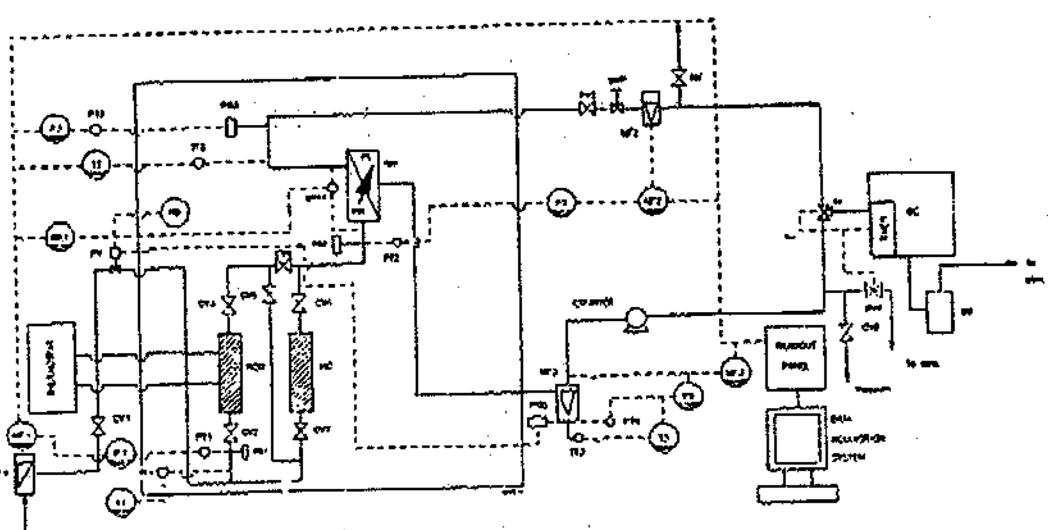


Figure 1. Schematic diagram of the Gas Separation Pilot Plant
(using membrane module - UNIT A)

Legend

MF	Mass Flowmeter	GC	Gas Chromatograph	MM	Membrane Module
CV	Control Valve	GI	Gas Indicator	PL	Low Pressure
HD	Hydrocarbon Detector	PT	Pressure Transducer	PH	High Pressure
DP	Differential Pressure	TT	Temperature Transducer	GR	Gas Regulator
PV	Pneumatic Valve	P	Pressure		
PG	Pressure Gauge	T	Temprature		
RV	Relieve Valve	TV	Tri-way Valve		
NV	Needle Valve	H2O	Water Saturator		
BPR	Back Pressure Regulator	HC	Hydrocarbon Saturator		